Monitoring OA, HABs, and more from NANOOS Cha'ba and NEMO buoys

Jan Newton[1, 4, 6] with many partners:

John Mickett[1], Simone Alin[2], Adrienne Sutton[2], Dick Feely[2], Stephanie Moore[3], Terrie Klinger[4], Nina Bednarsek[5], Parker MacCready[6], Samantha Siedlecki[7]

1: UW-APL; 2: NOAA PMEL; 3: NOAA NWFSC; 4: UW-SMEA; 5: IPCC; 6: UW-Oceanography; 7: UW-JISAO

NANOOS

IOOS Integrated Ocean Observing System

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

W

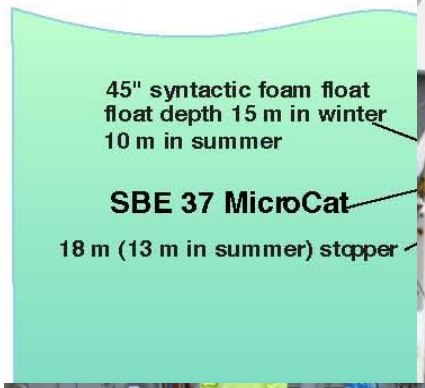

complex area…

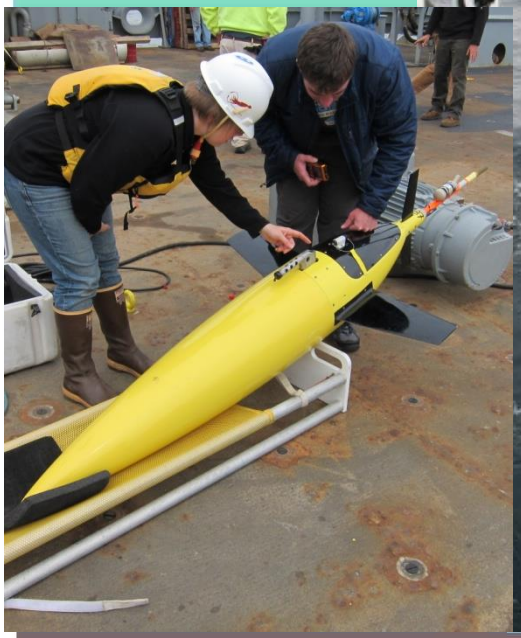
2009 Science Issues

- WA coast is under sampled, physical dynamics are poorly resolved
- WA coast has seasonal hypoxia, strong inter-annual variation, but dynamics are different than off OR
- WA coast has a harmful algal bloom (HAB) “hot-spot” at Juan de Fuca eddy
- WA coast is exhibiting effects from OA now
- Current model accuracy is limited by data input

“A multi-platform high-resolution coastal ocean observing sensor array for researching Washington coastal waters and ecosystem response to climate change.”

Funded by Murdock Charitable Trust & UW now sustained as part of NANOOS






Ch̓a'ba'
"Whale Tail"

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

'Like putting headlights on a car'

Pacific oysters gain from IOOS® data

Promoting Economic Vitality

About six years ago, production at some Pacific Northwest oyster hatcheries began declining at an alarming rate, posing severe economic impact and challenging a way of life held by shellfish growers for more than 130 years.

By 2008, the oyster harvest at Whiskey Creek, a major Oregon supplier to the majority of West Coast oyster farmers, plummeted 80 percent. At about the same time, corrosive, acidified seawater was hitting the shores of the Pacific.

Something had to be done. Oyster production accounts for more than $84 million of the West Coast shellfish industry, which supports more than 3,000 jobs.

"When you see oyster shells dissolving in water, there's a compelling need to know why," says Bill Dewey of Taylor Shellfish Farms in Washington state.

Thanks to a $500,000 federal investment in monitoring coastal seawater strengthened by data and observational information from the U.S. **Integrated Ocean Observing System** (IOOS®) and the **NOAA Ocean Acidification Program**, oyster hatcheries on the verge of collapse just a few years ago are again major contributors to the $111 million West Coast shellfish industry.

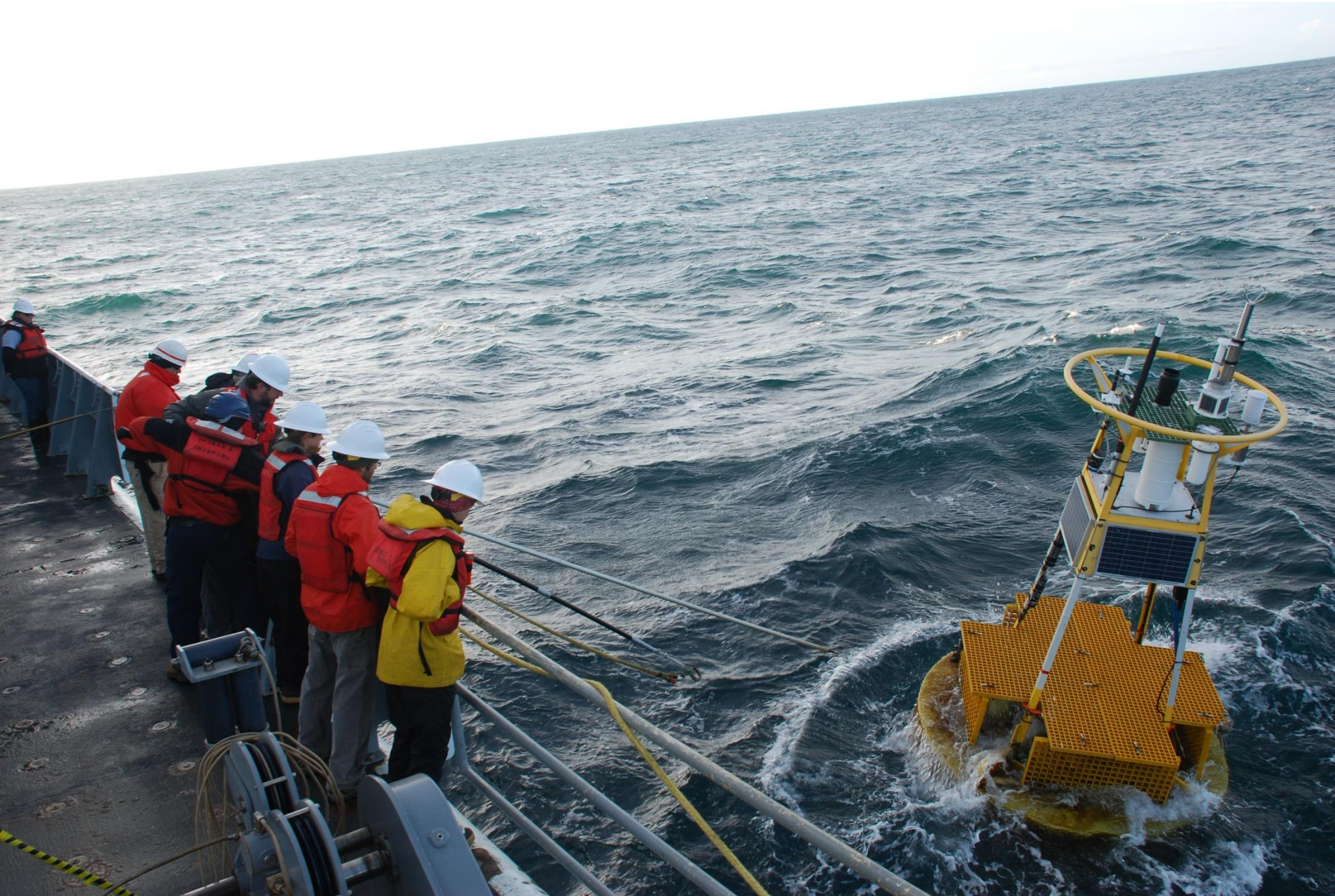
IOOS is a NOAA-led interagency and regional effort aimed at "knowing" — that

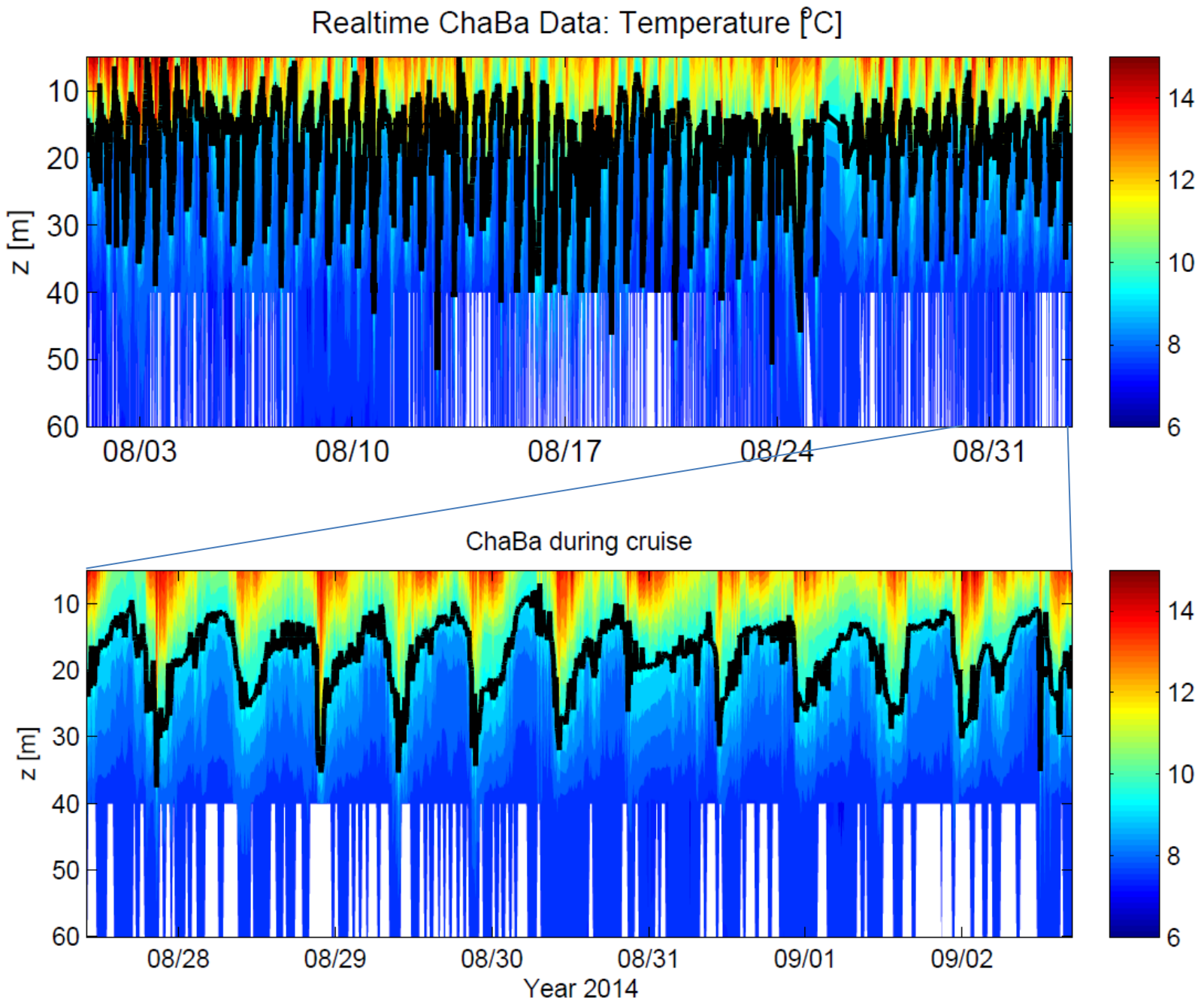
IOOS partners in the Northwest Association of Networked Ocean Observing Systems (NANOOS) deployed this buoy in 2010 as part of a three-piece observing array to assess issues in the Northwest, including **ocean acidification**, **hypoxia and harmful algal blooms**, and **climate change**. The coastal buoy will aid computer models that predict ocean and atmospheric conditions. Known as "Chá bă," the buoy is named for the Native American word (pronounced "chay buh") for "whale tail."

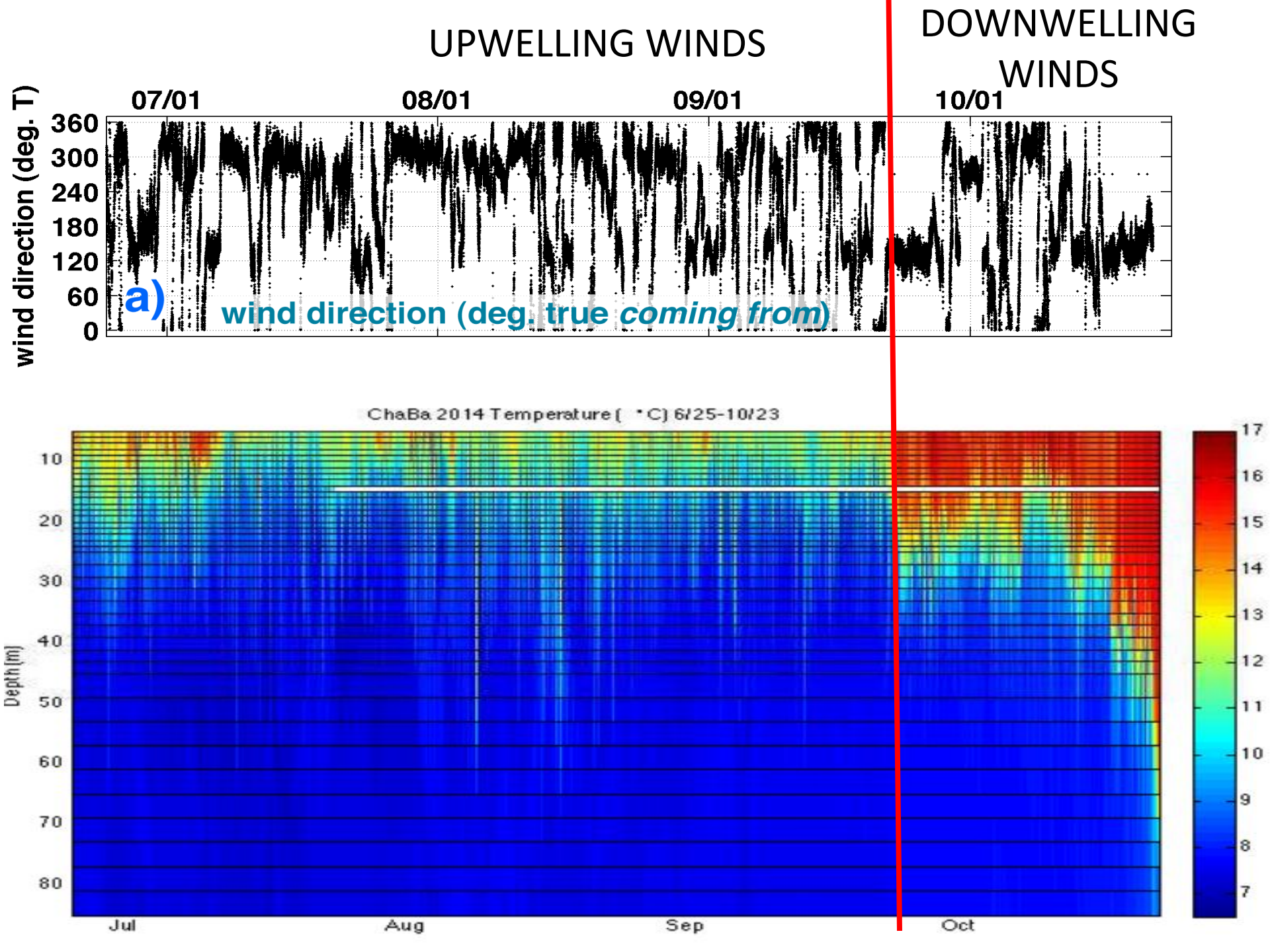
(Photo courtesy of Dr. John Payne, Pacific Ocean Shelf

NANOOS

"Putting an IOOS buoy in the water is like putting headlights on a car. It lets us see changing water conditions in real time," says Mark Wiegardt, co-owner of Whiskey Creek Shellfish Hatchery.

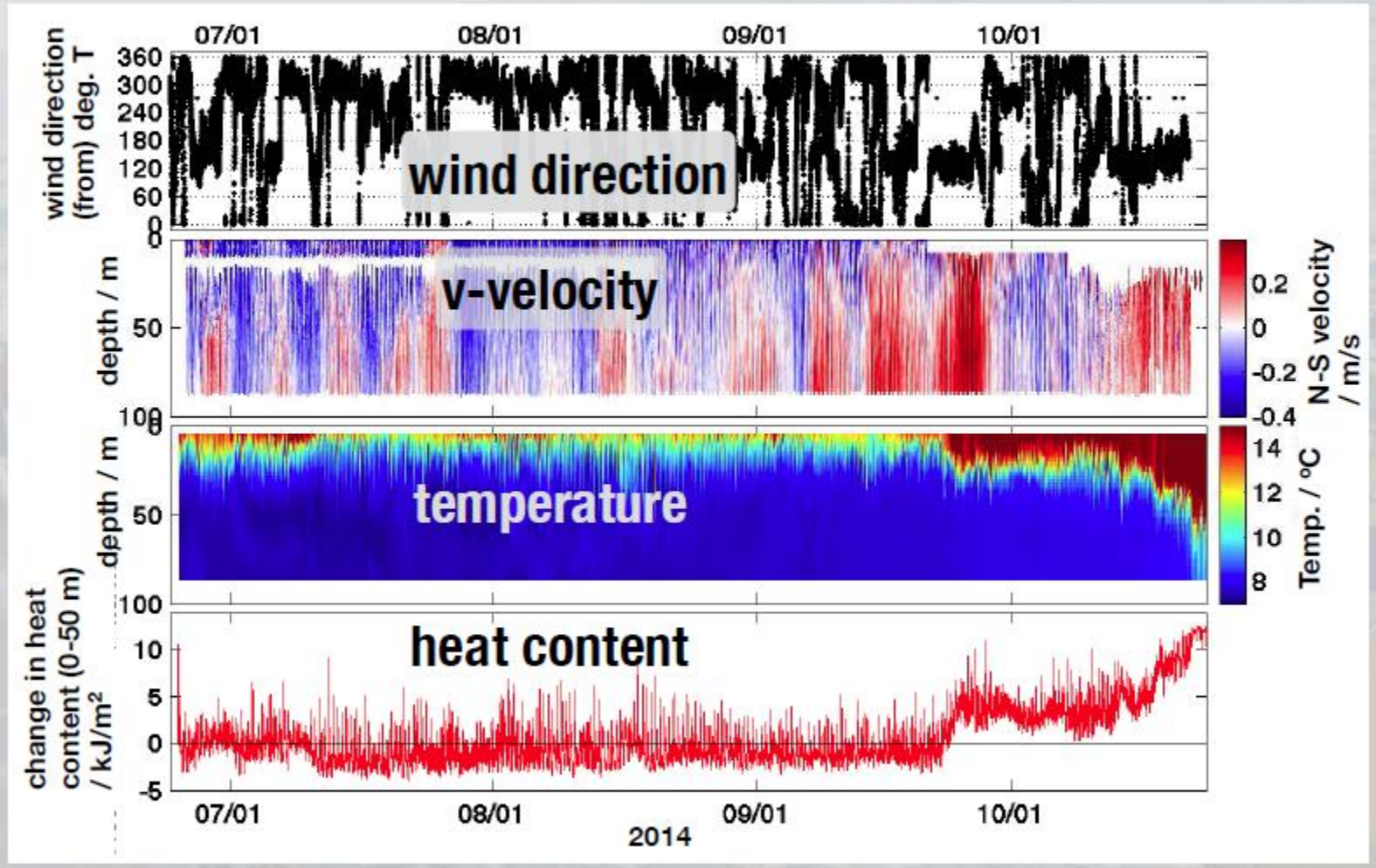



Realtime ChaBa Data: Temperature [°C]
z [m]
10
20
30
40
50
60
08/03
08/10
08/17
08/24
08/31
14
12
10
8
6
ChaBa during cruise
z [m]
10
20
30
40
50
60
08/28
08/29
08/30
08/31
09/01
09/02
Year 2014
14
12
10
8
6


UPWELLING WINDS
DOWNWELLING WINDS
07/01
08/01
09/01
10/01
wind direction (deg. T)
360
300
240
180
120
60
0
a)
wind direction (deg. true coming from)
ChaBa 2014 Temperature (°C) 6/25-10/23
Depth (m)
10
20
30
40
50
60
70
80
Jul
Aug
Sep
Oct
17
16
15
14
13
12
11
10
9
8
7

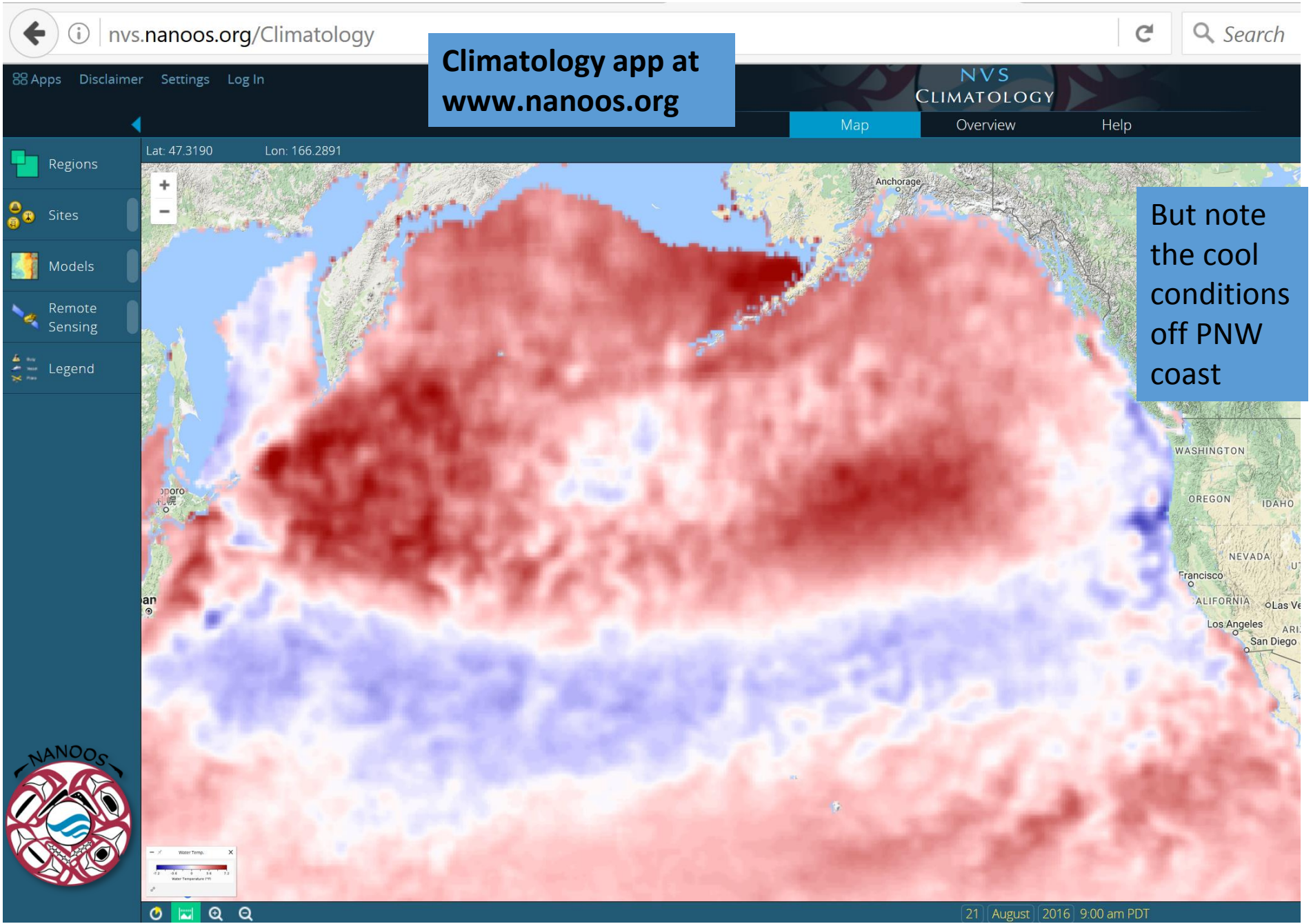
NEMO: Recent Successes

Measuring the "Blob" as it came ashore in the fall of 2014

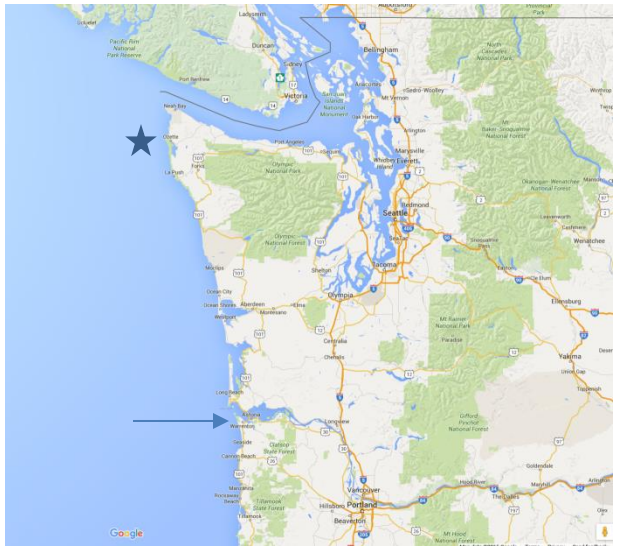


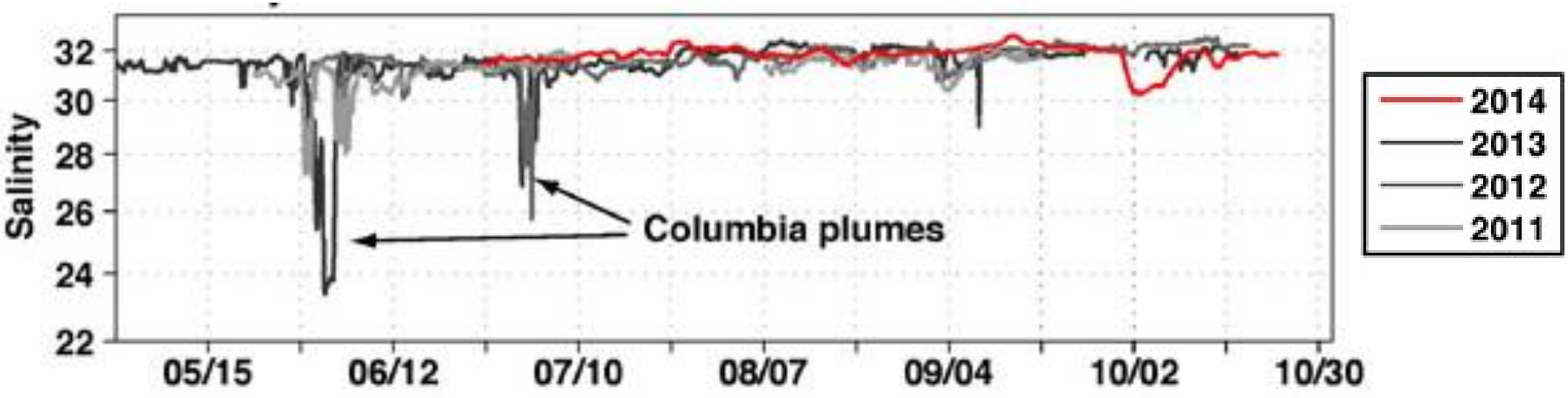
- These were among the few full-depth, high-resolution measurements of this process.
- The measurements greatly complimented satellite observations of SST.

The “blob,” aka marine heat wave, is back….(*or actually never really left)*

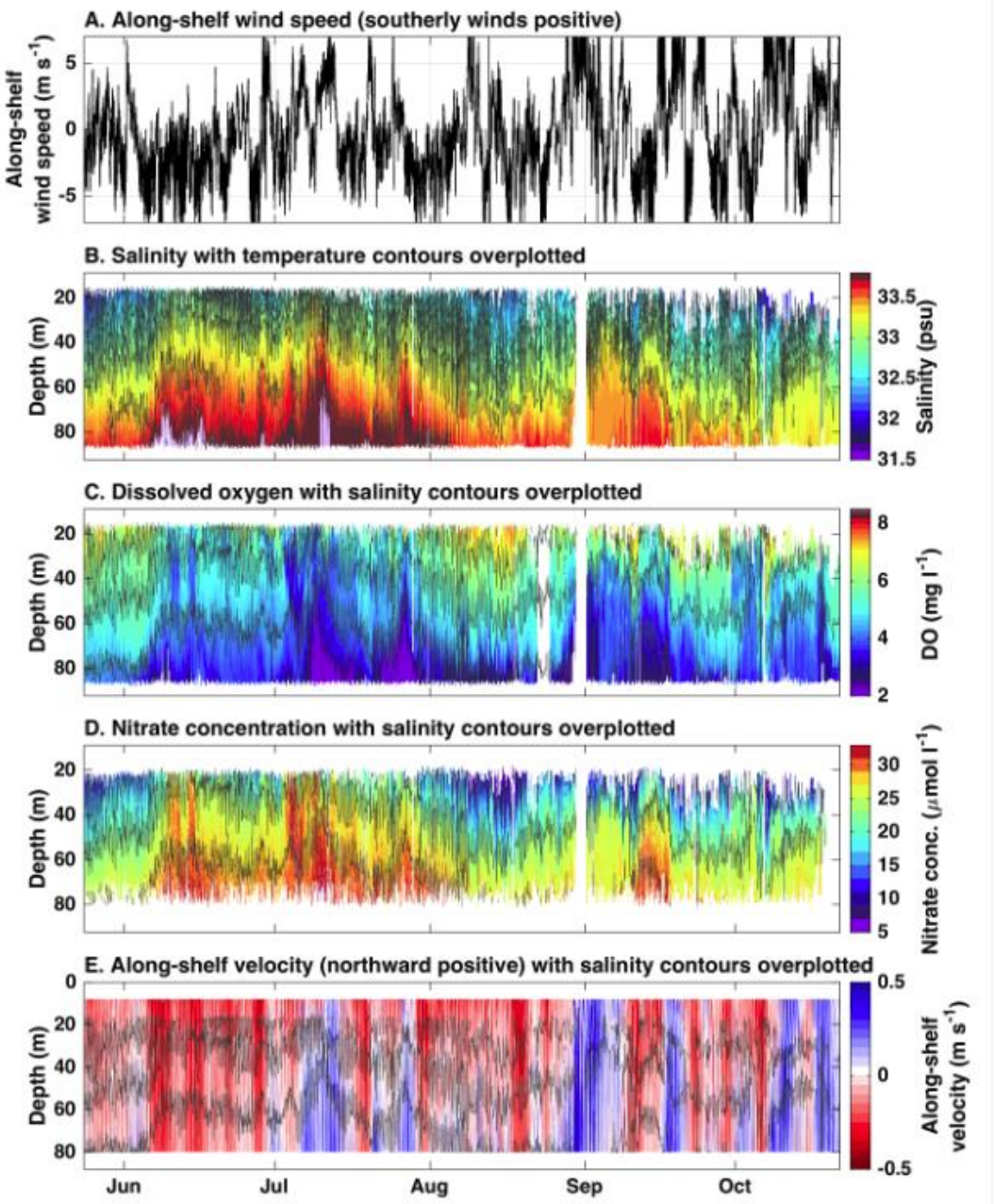


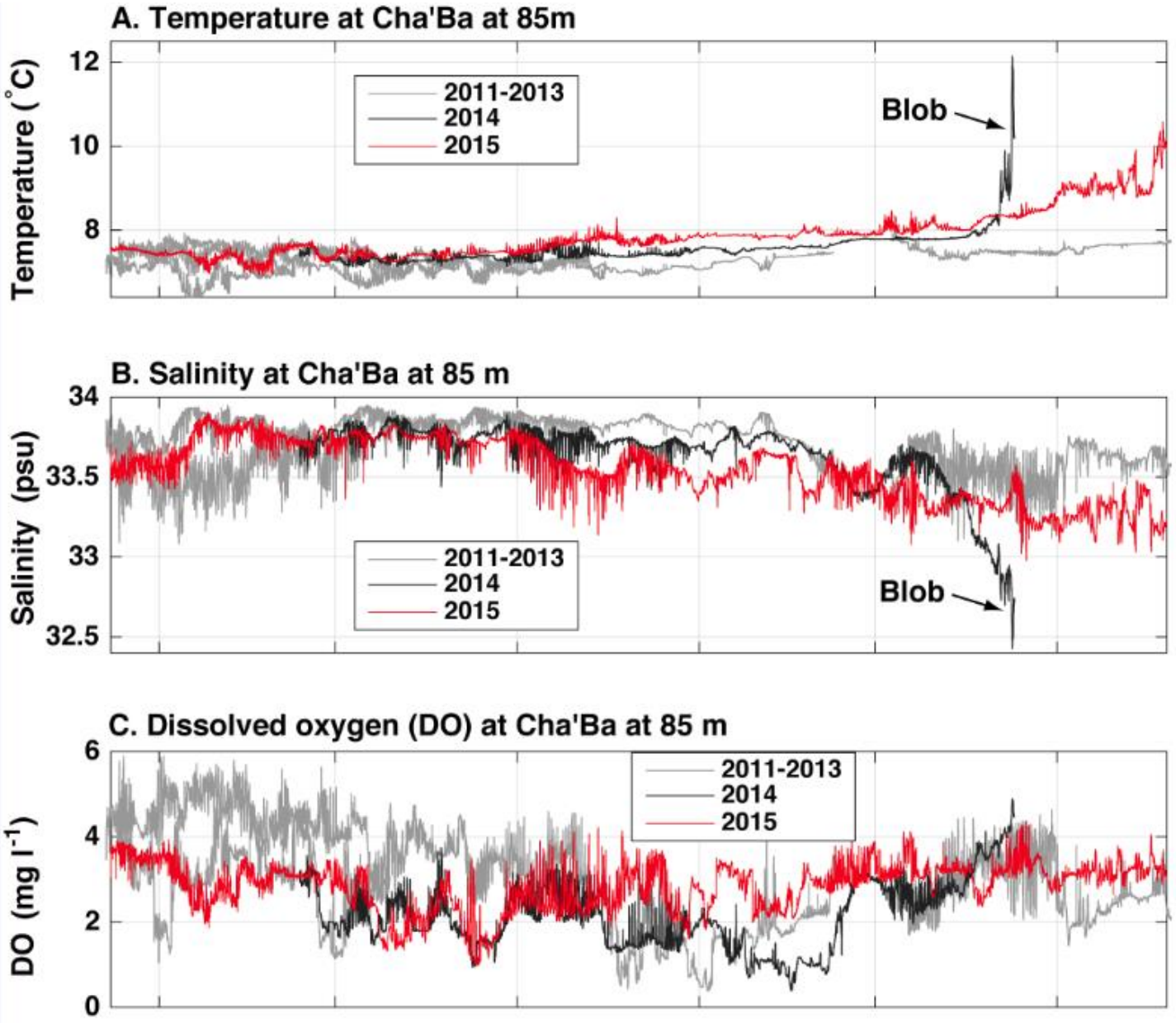
Better definition of Columbia River influence

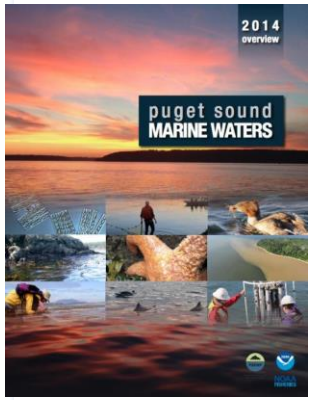




- PSEMP Marine Waters Workgroup. 2015. Puget Sound marine waters: 2014 overview. S. K. Moore, R. Wold, K. Stark, J. Bos, P. Williams, K. Dzinbal, C. Krembs and J. Newton (Eds). URL: *http://www.psp.wa.gov/PSEMP/PSmarinewatersoverview.php.*

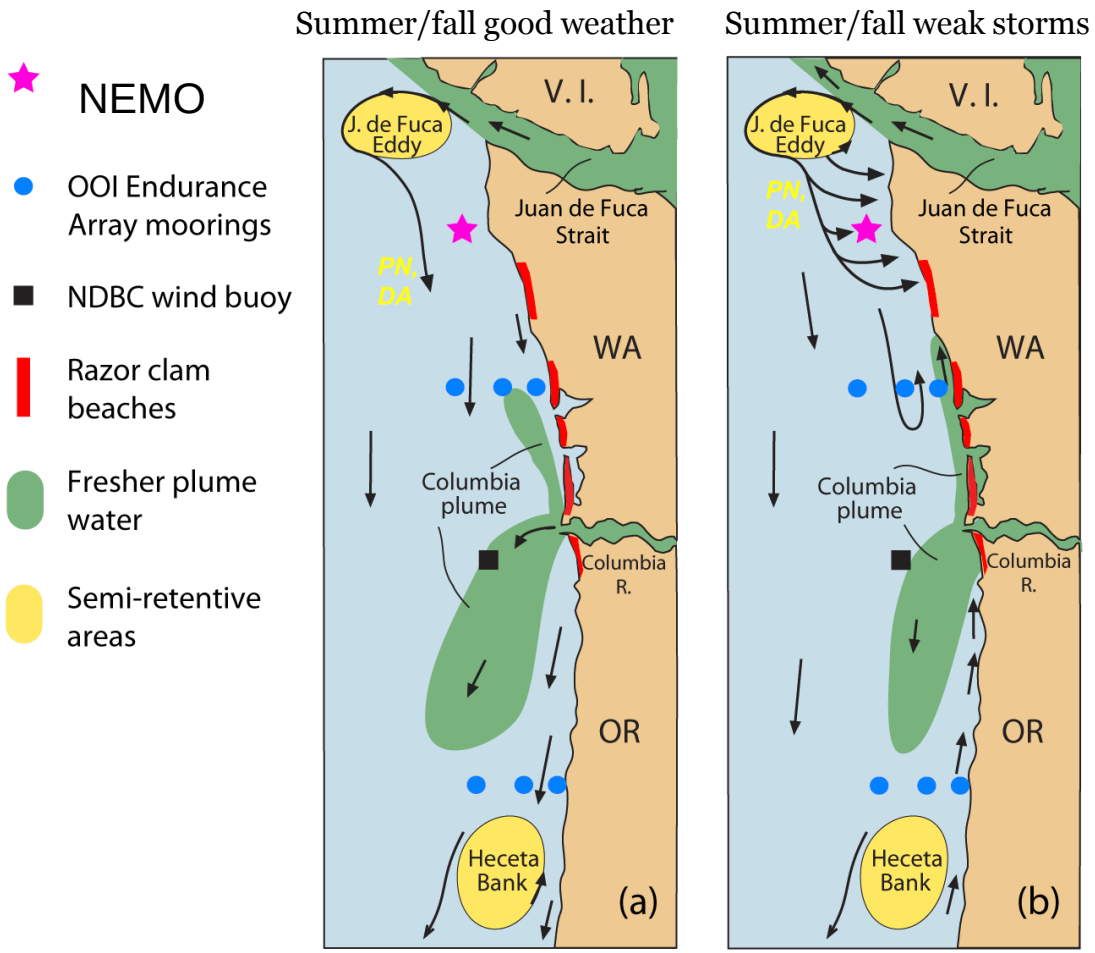

A. Along-shelf wind speed (southerly winds positive)
Along-shelf wind speed (m s-1)
5
0
-5
B. Salinity with temperature contours overplotted
Depth (m)
20
40
60
80
33.5
33
32.5
32
31.5
Salinity (psu)
C. Dissolved oxygen with salinity contours overplotted
Depth (m)
20
40
60
80
8
6
4
2
DO (mg l-1)
D. Nitrate concentration with salinity contours overplotted
Depth (m)
20
40
60
80
30
25
20
15
10
5
Nitrate conc. (μmol l-1)
E. Along-shelf velocity (northward positive) with salinity contours overplotted
Depth (m)
0
20
40
60
80
0.5
0
-0.5
Along-shelf velocity (m s-1)
Jun
Jul
Aug
Sep
Oct





PSEMP Marine Waters Overviews

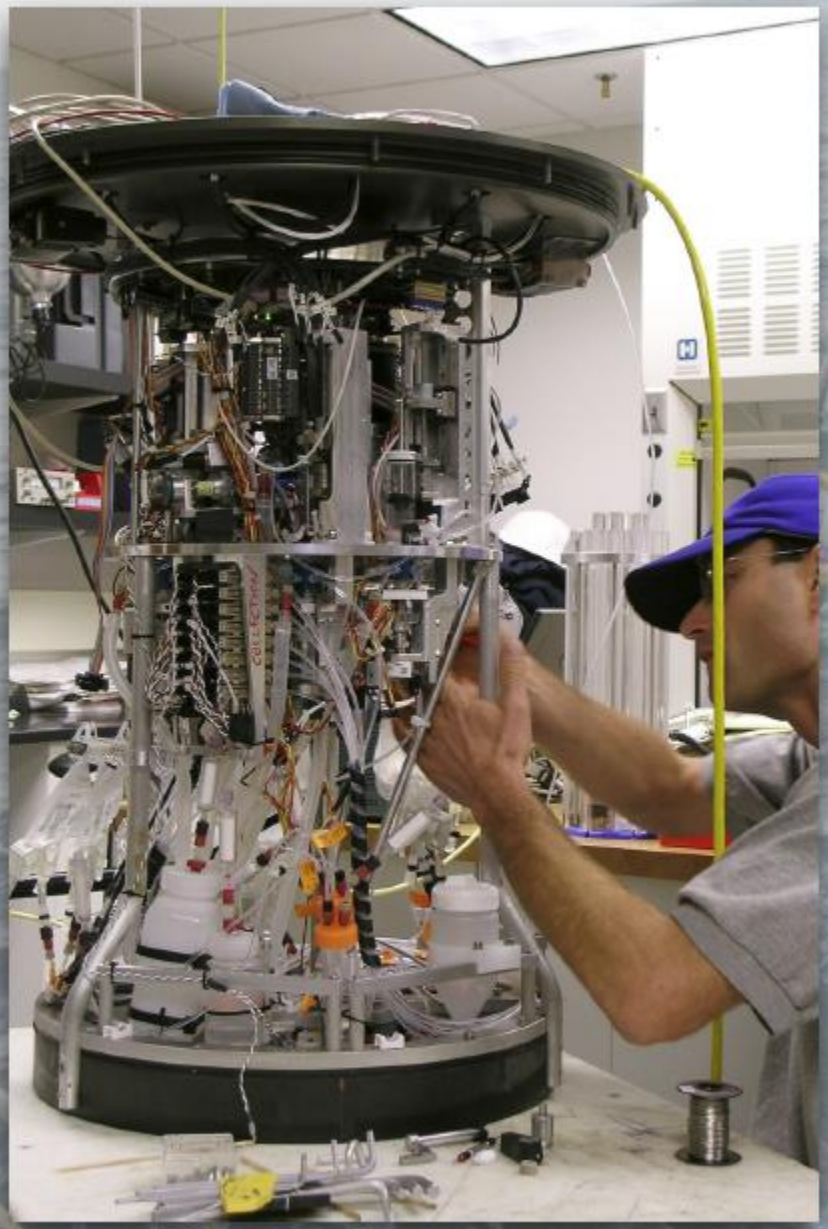
ESP deployed on existing moored observatory in transport pathway



[Modified from Hickey et al. 2013]

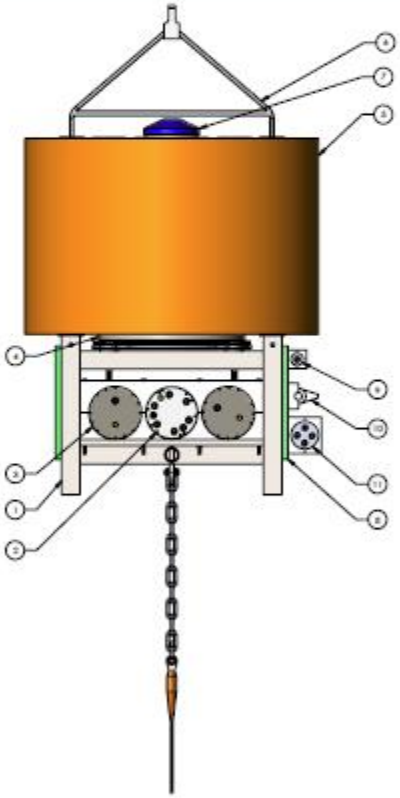
NEMO Environmental Sample Processor (ESP)

- The ESP: a real-time harmful algal bloom (HAB)-detection system (MBARI)
- A complex lab-in-a-can that does in-situ DNA analysis, ID'ing target species and associated toxin
- WA razor clam fishery alone experiences an estimated $24.4 million in lost revenue when closed to HABs. Dungeness crab also important.
- Significant human health aspect
- Can cause severe ecosystem impacts on higher tropic levels.
- The real-time mooring will be an early-detection system to enable rapid resource management and human health decisions.
- Will be integrated into the NEMO subsurface mooring, with first operational deployment scheduled for this May.

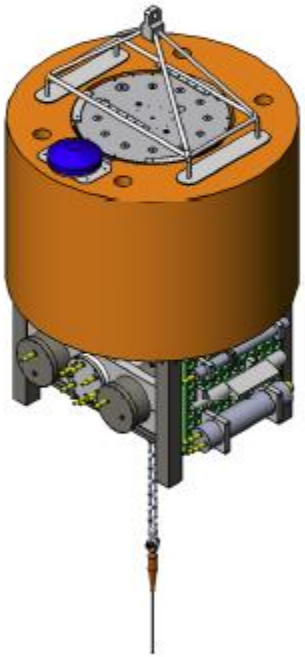


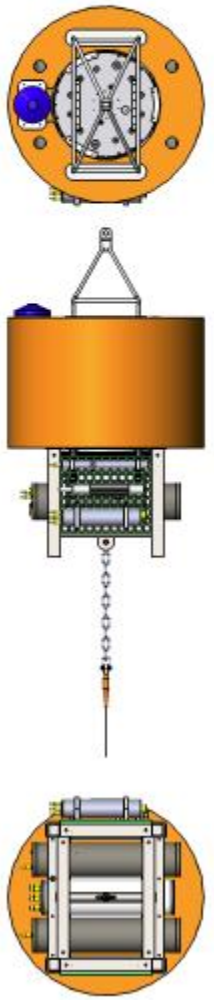
NEMO Environmental Sample Processor

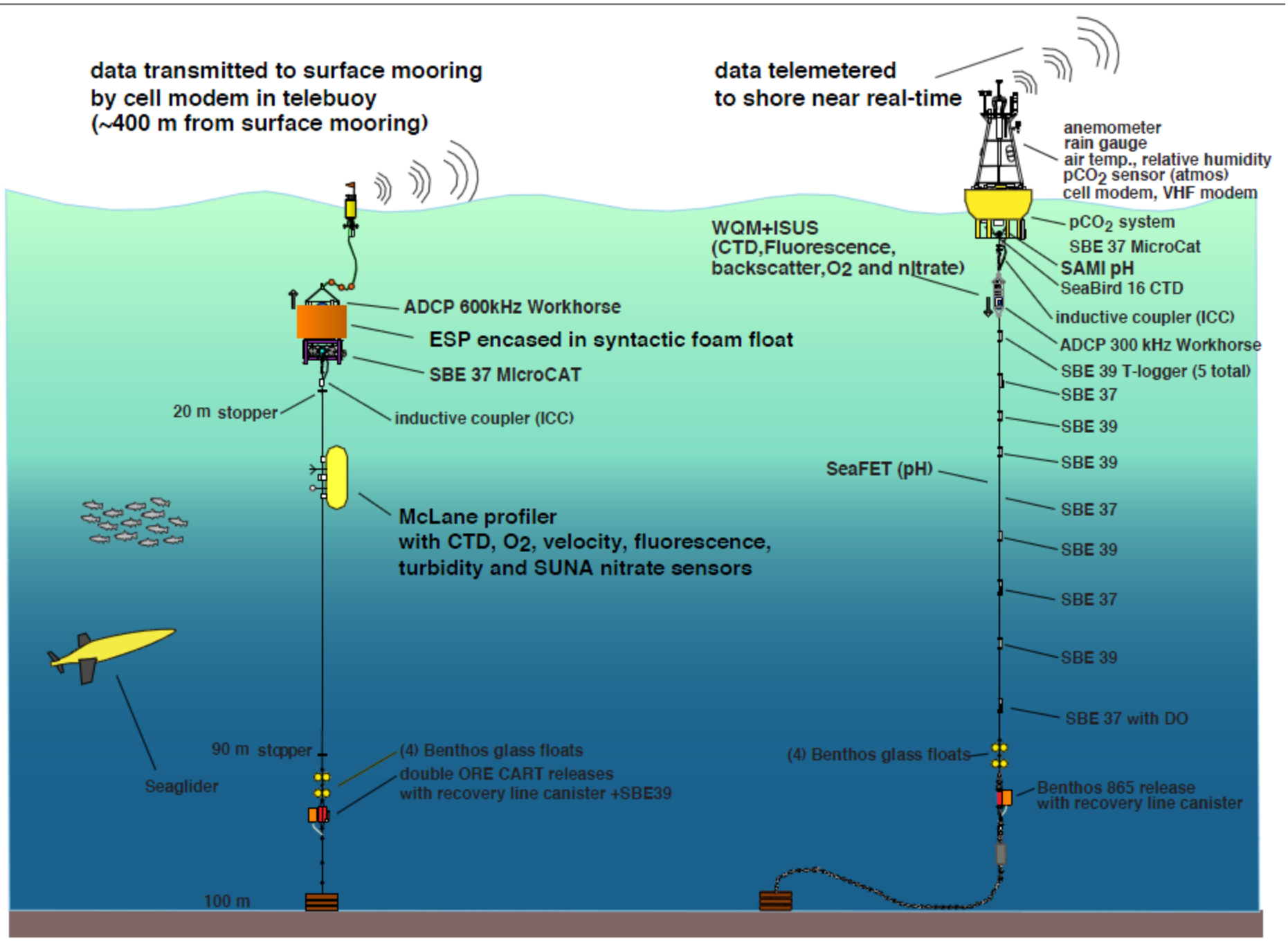
- APL lead of 7-institution effort.
- designed and built the mooring infrastructure, pressure case, power system, telemetry system, and pump sampling system.
- significantly expands the scope of deployment environments for the ESP.

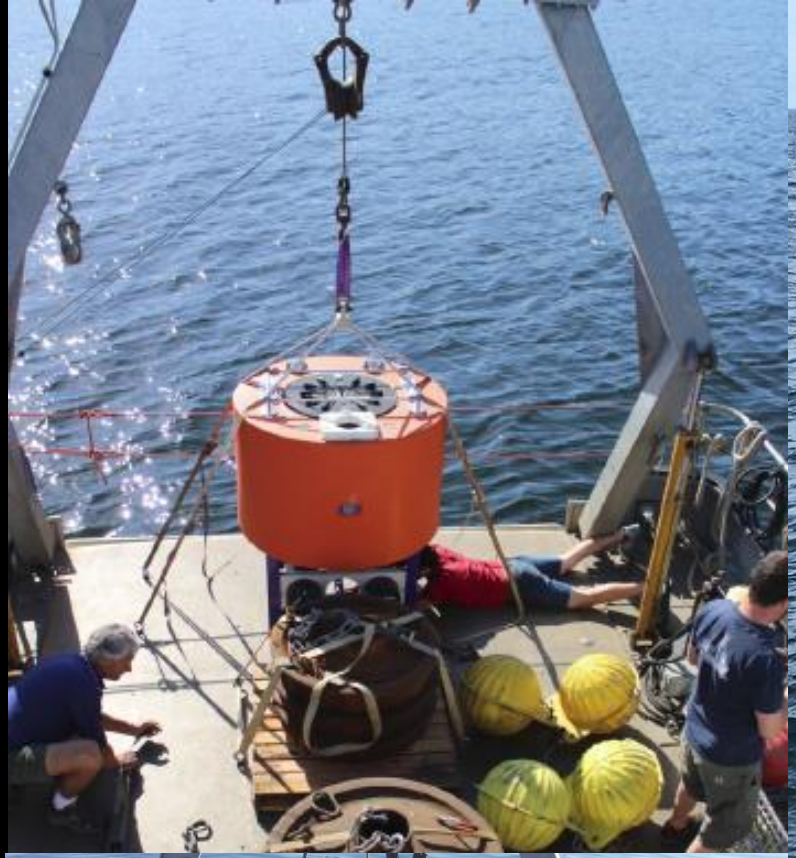


ITEM NO.	DESCRIPTION	QTY.
1	FRAME BASE, GALVANIZED STEEL	1
2	NEMO MOORING CONTROLLER	1
3	ESP BATTERY HOUSING	2
4	ESP ASSEMBLY	1
5	750M SYNTACTIC FOAM	1
6	THRU LIFT FRAME, 316SS	1
7	TELEDYNE SENTINEL ADCP	1
8	FIBERGLASS GRATING	2
9	SATLANTIC SUNA	1
10	SEABIRD 37	1
11	SATLANTIC SEAFET	1






data transmitted to surface mooring
by cell modem in telebuoy
(~400 m from surface mooring)
data telemetered
to shore near real-time
anemometer
rain gauge
air temp., relative humidity
pCO2 sensor (atmos)
cell modem, VHF modem
pCO2 system
SBE 37 MicroCat
SAMI pH
SeaBird 16 CTD
inductive coupler (ICC)
ADCP 300 kHz Workhorse
SBE 39 T-logger (5 total)
SBE 37
SBE 39
SBE 39
SBE 37
SBE 39
SBE 37
SBE 39
SBE 37 with DO
WQM+ISUS
(CTD,Fluorescence,
backscatter,O2 and nitrate)
SeaFET (pH)
ADCP 600kHz Workhorse
ESP encased in syntactic foam float
SBE 37 MIcroCAT
20 m stopper
inductive coupler (ICC)
McLane profiler
with CTD, O2, velocity, fluorescence,
turbidity and SUNA nitrate sensors
Seaglider
90 m stopper
(4) Benthos glass floats
double ORE CART releases
with recovery line canister +SBE39
(4) Benthos glass floats
Benthos 865 release
with recovery line canister
100 m



Cha'ba is a national OA buoy…

www.pmel.noaa.gov/co2/story/Strategy+for+OA+Observations

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PMEL CARBON PROGRAM

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Strategy for OA Observations

PMEL is developing a global network of ocean acidification observations

The existing global carbon observatory network of repeat hydrographic surveys, time-series stations and ship-based underway surface observations in the open ocean provide a strong foundation of carbon chemistry observations to begin addressing the problem of ocean acidification. Indeed, much of our present understanding of the long-term changes in the carbon system is derived from the repeat ocean sections and time-series measurements.

Location of planned OA monitoring and research sites and affiliated NOAA labs.

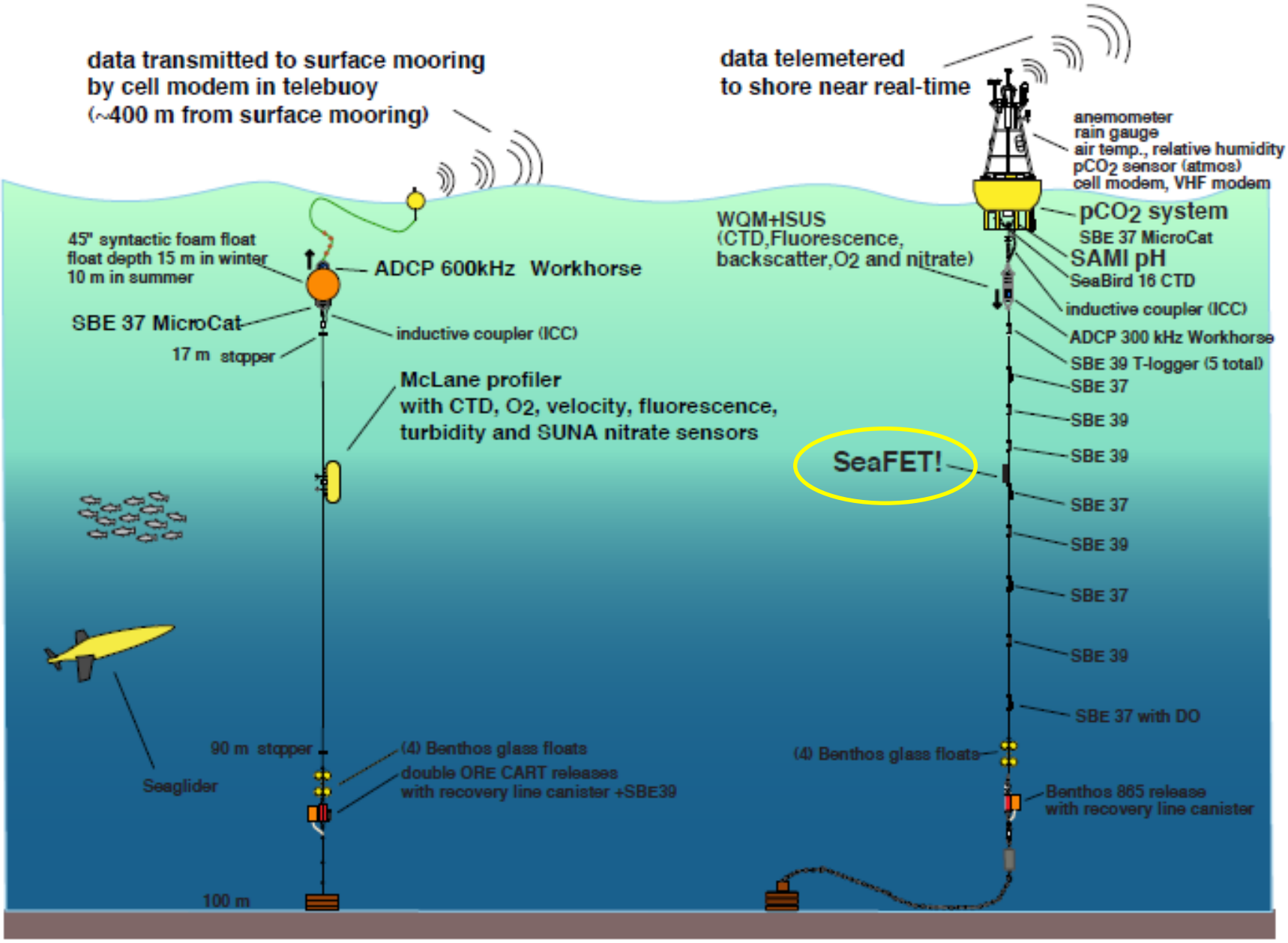
A major project for our group is to **expand the global moored and ship-based network by adding pH and other biogeochemical measurements** to provide important information on the changing conditions in the open ocean and coastal waters. See the map of planned monitoring sites to the right. This network will provide a better understanding of the temporal and spatial scales of variability in ocean carbon chemistry and biology and the observational basis for developing predictive models for future changes in ocean acidification and its consequences for marine ecosystems.

U.S. **coastal and estuarine environments** do not currently have coordinated carbon observing networks, as in the open ocean, and are presently grossly under-sampled. There is a critical need for intensive time series measurements on moored buoys and repeat hydrographic cruises in high productivity coastal and estuarine systems as CO_2 and carbonate ion concentrations in these waters can vary substantially on timescales from hours to decades due to tides, photosynthesis, and river or ground water inputs. In response to that need, we are adding carbon and pH sensors to

RELATED STORIES

Ocean Acidifica …
Fundamental changes in seawater chemistry are occurring throu …

NOAA OA Plan
NOAA researchers and managers are working to


data transmitted to surface mooring
by cell modem in telebuoy
(~400 m from surface mooring)
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to shore near real-time
anemometer
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SBE 39
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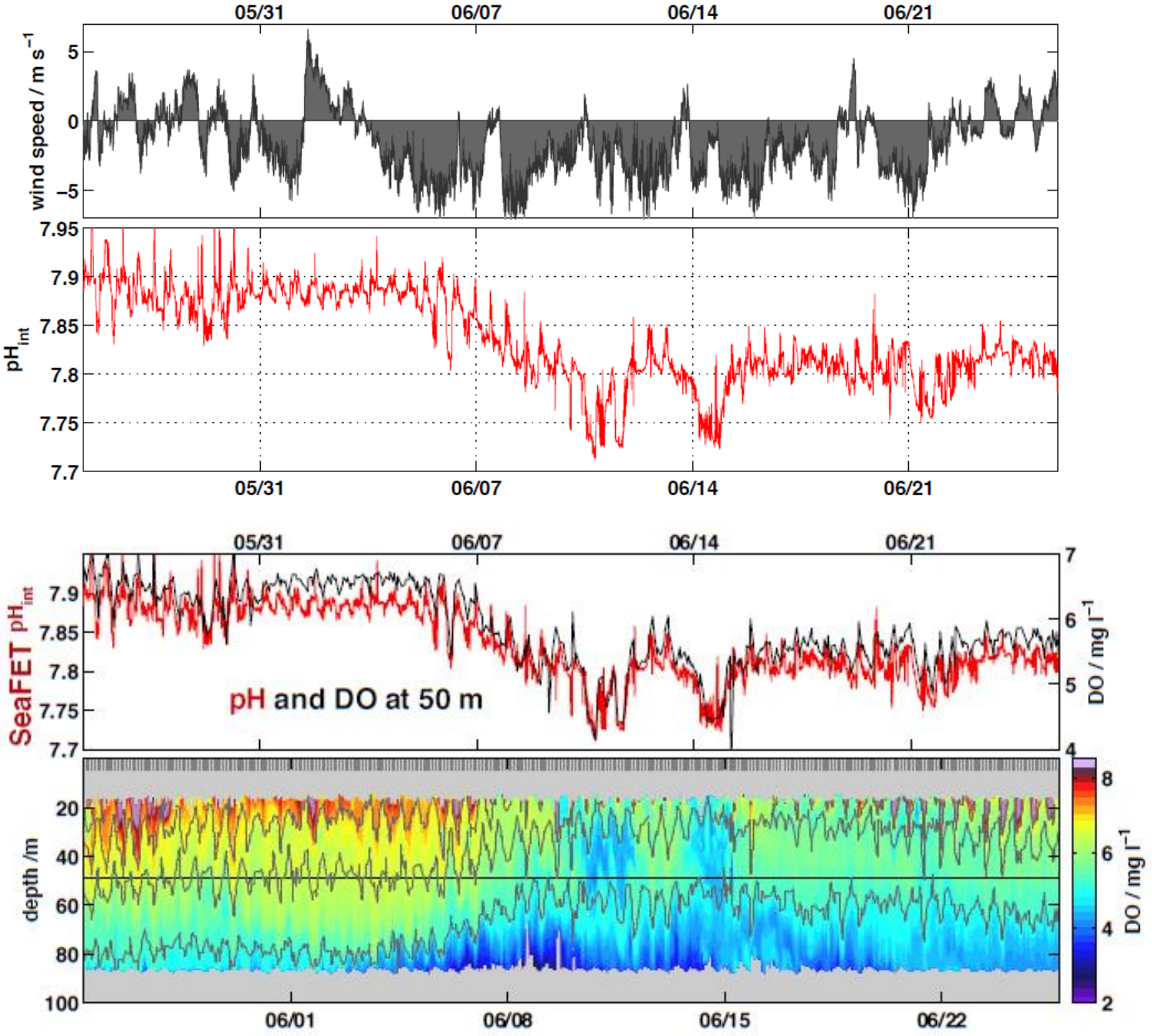
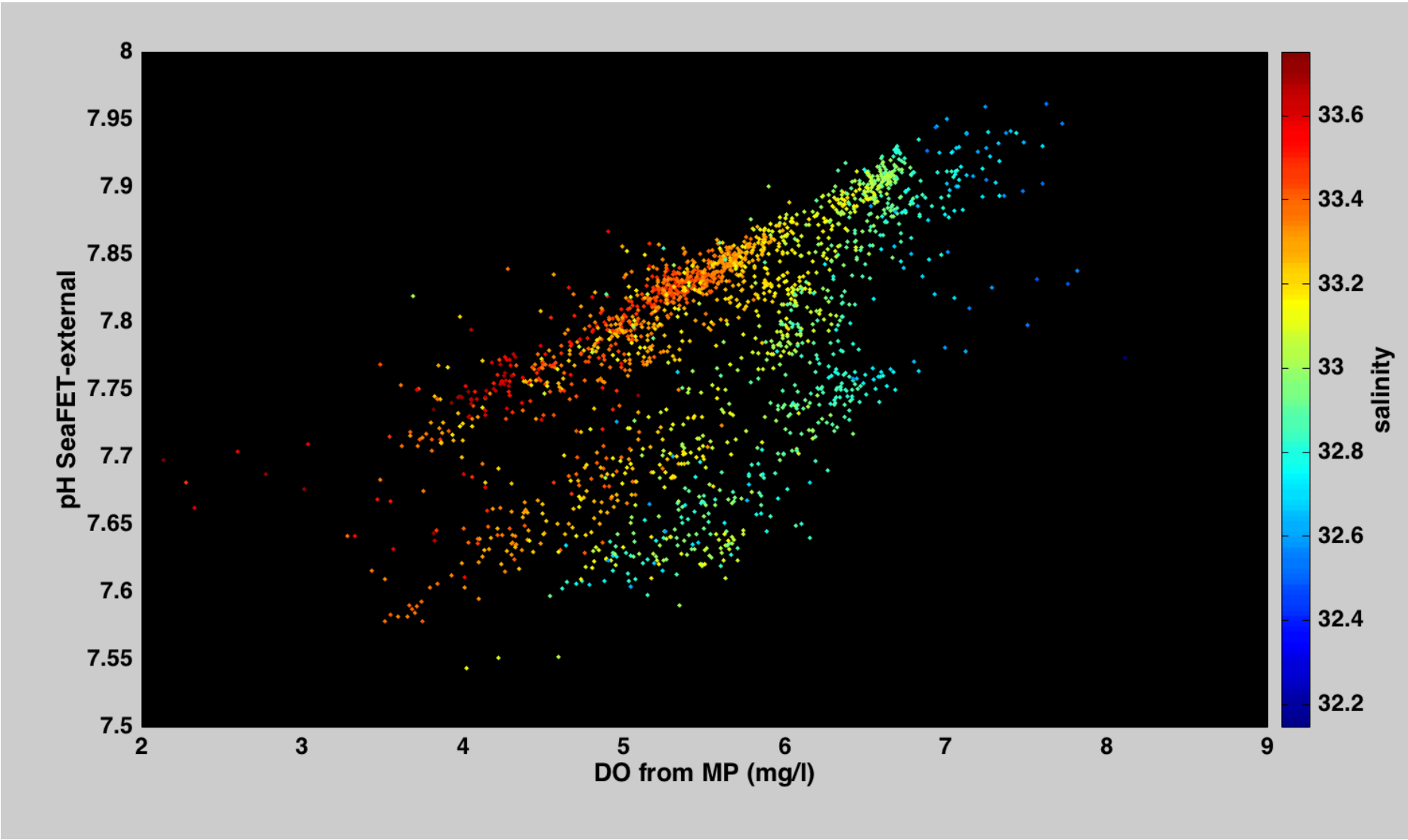
SBE 37
SBE 39
SBE 37 with DO
(4) Benthos glass floats
Benthos 865 release
with recovery line canister
WQM+ISUS
(CTD,Fluorescence,
backscatter,O2 and nitrate)
SeaFET!
45" syntactic foam float
float depth 15 m in winter
10 m in summer
ADCP 600kHz Workhorse
SBE 37 MicroCat
inductive coupler (ICC)
17 m stopper
McLane profiler
with CTD, O2, velocity, fluorescence,
turbidity and SUNA nitrate sensors
Seaglider
90 m stopper
(4) Benthos glass floats
double ORE CART releases
with recovery line canister +SBE39
100 m

Wind

pH


05/31
06/07
06/14
06/21
wind speed / m s^{-1}
5
0
−5
7.95
7.9
7.85
7.8
7.75
7.7
pH$_{int}$
SeaFET pH$_{int}$
pH and DO at 50 m
DO / mg l^{-1}
7
6
5
4
depth /m
20
40
60
80
100
8
6
4
2
06/01
06/08
06/15
06/22

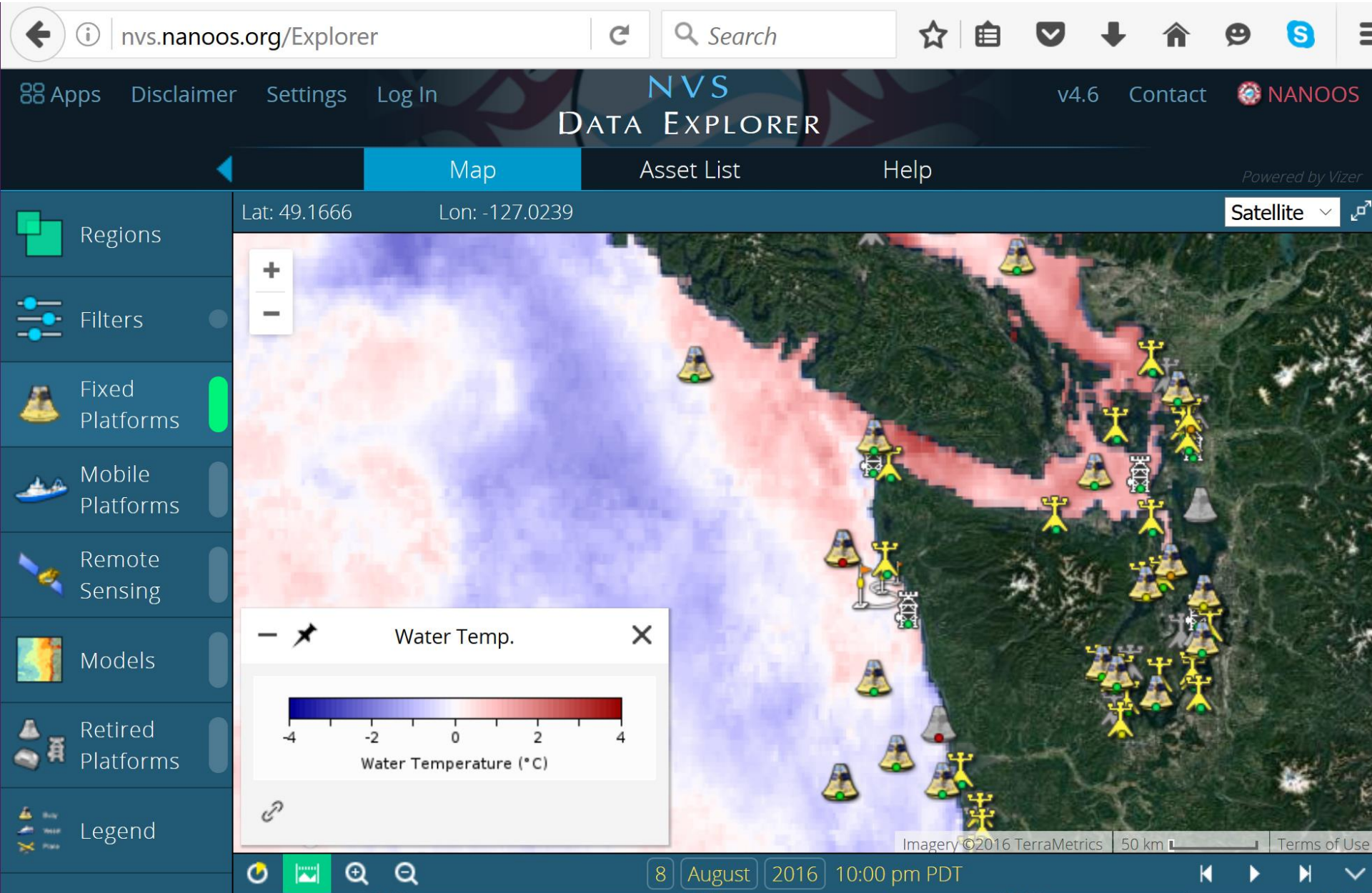
DO and pH relations



2015 Science Reality

- WA coast is sampled in near real-time; physical dynamics revealed and published
- WA coast has seasonal hypoxia; dynamics can be observed by tribes and agencies in real-time
- WA coast has a HAB “hot-spot”; now status will be monitored for toxicity in real-time
- WA coast is exhibiting effects from OA now, observed by a NOAA OAP buoy (Cha’ba) year-round
- Current model accuracy is increased and skill can be verified by the on-line “comparator”

NANOOS observations and data

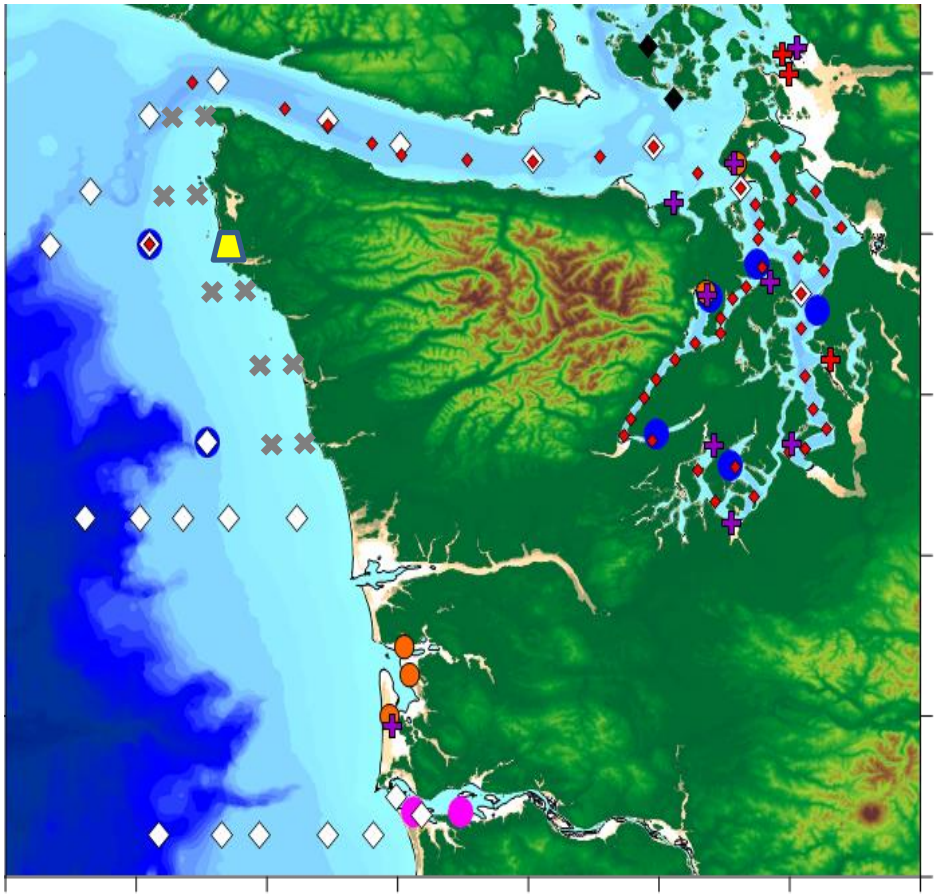


Washington Ocean Acidification Center implementing key recommendations

Coordinate and synthesize science to:

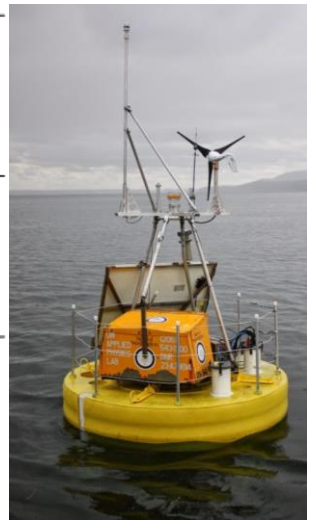
1. ***Assess water conditions and what's driving ocean acidification***
   - Monitoring (both in natural environment and at shellfish hatcheries)
2. ***Provide forecasts to facilitate adaptation***
   - Forecast modeling
3. ***Assess how local species respond***
   - Biological experiments
4. ***Inform aquaculture practices***
   - Shellfish culture adaptation

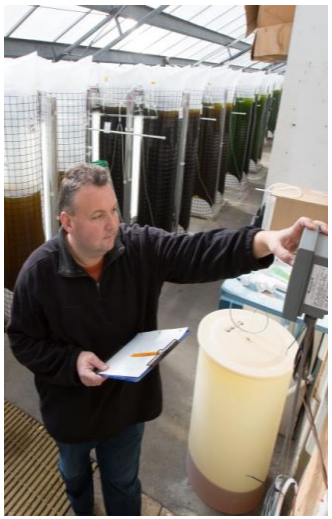
1. Assess OA and biological response



Strategies:

- Both **chemistry** (DIC, TA) and **biology** measurements
- **Temporal** trends (buoys) & **spatial** coverage (surveys)
- **Leverages** existing networks

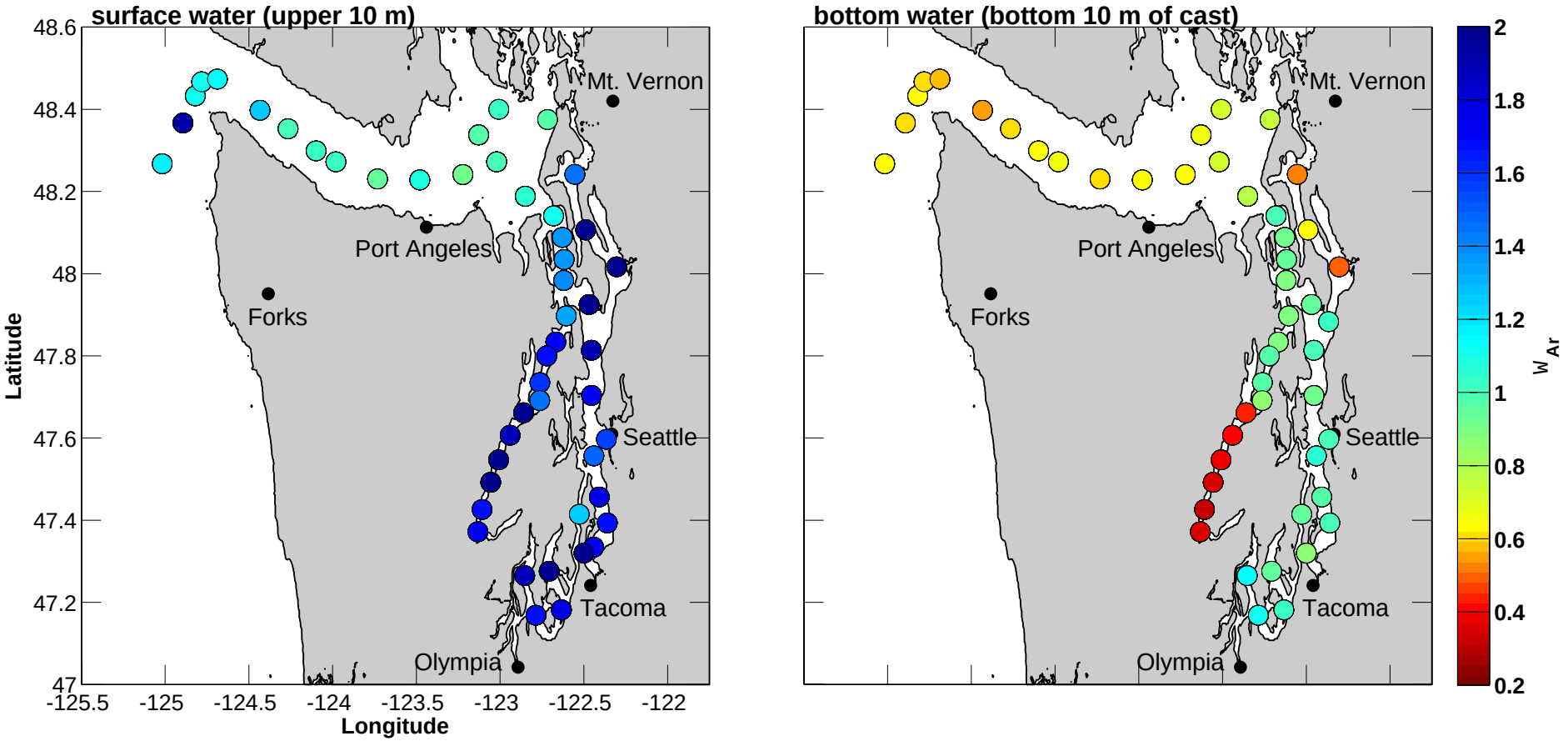




Map: Greeley; Photos: Vander Giessen & USA Today

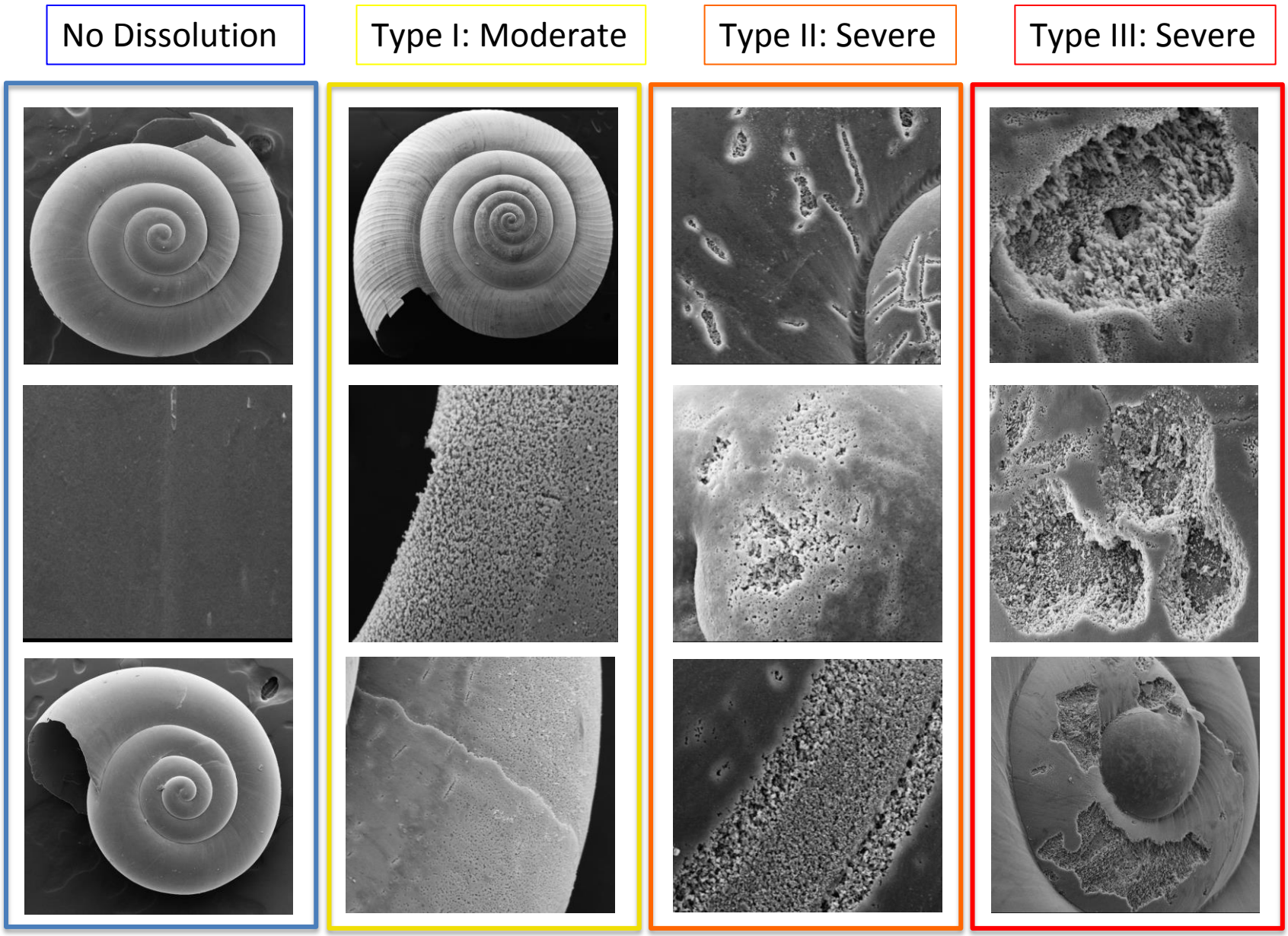
Washington water chemistry

Ω_{arag}



With Feely, Alin, et al., NOAA

Pteropods as bio-indicators

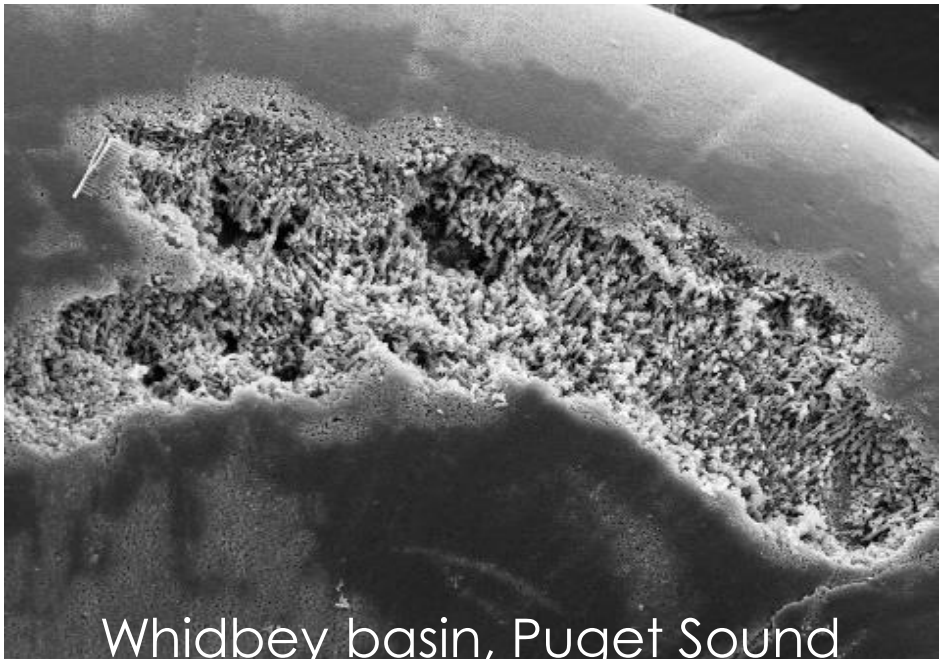


Nina Bednarsek and Jessamyn Johnson, UW

WA OA Center monitoring: *bioindicator*

- Pteropod shells show signs of dissolution
- Patterns in time and space help us understand impacts and drivers

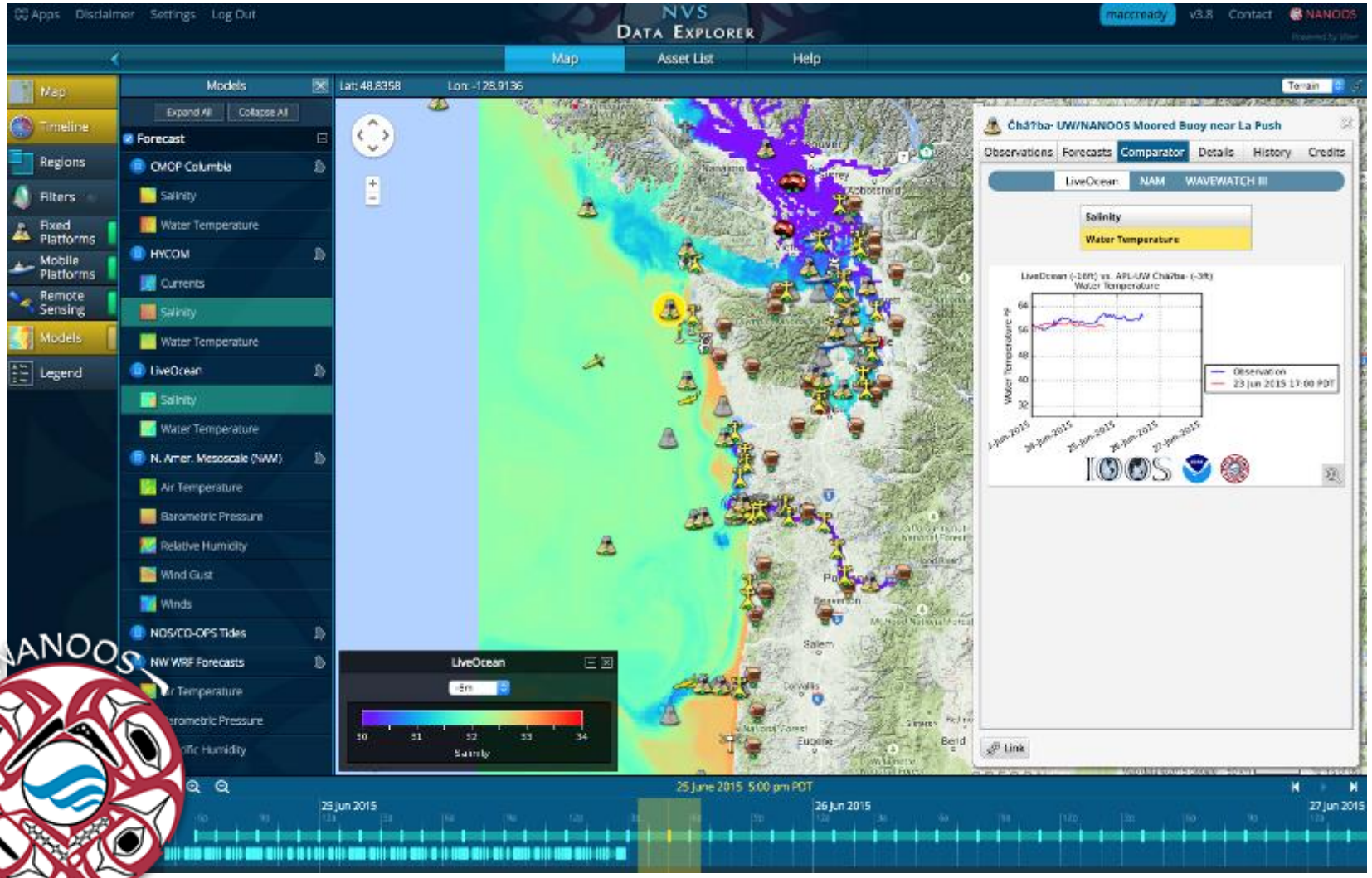

La Push, coastal WA


Whidbey basin, Puget Sound

Photos: Johnson & Bednarsek

Near-term predictions of OA in Washington

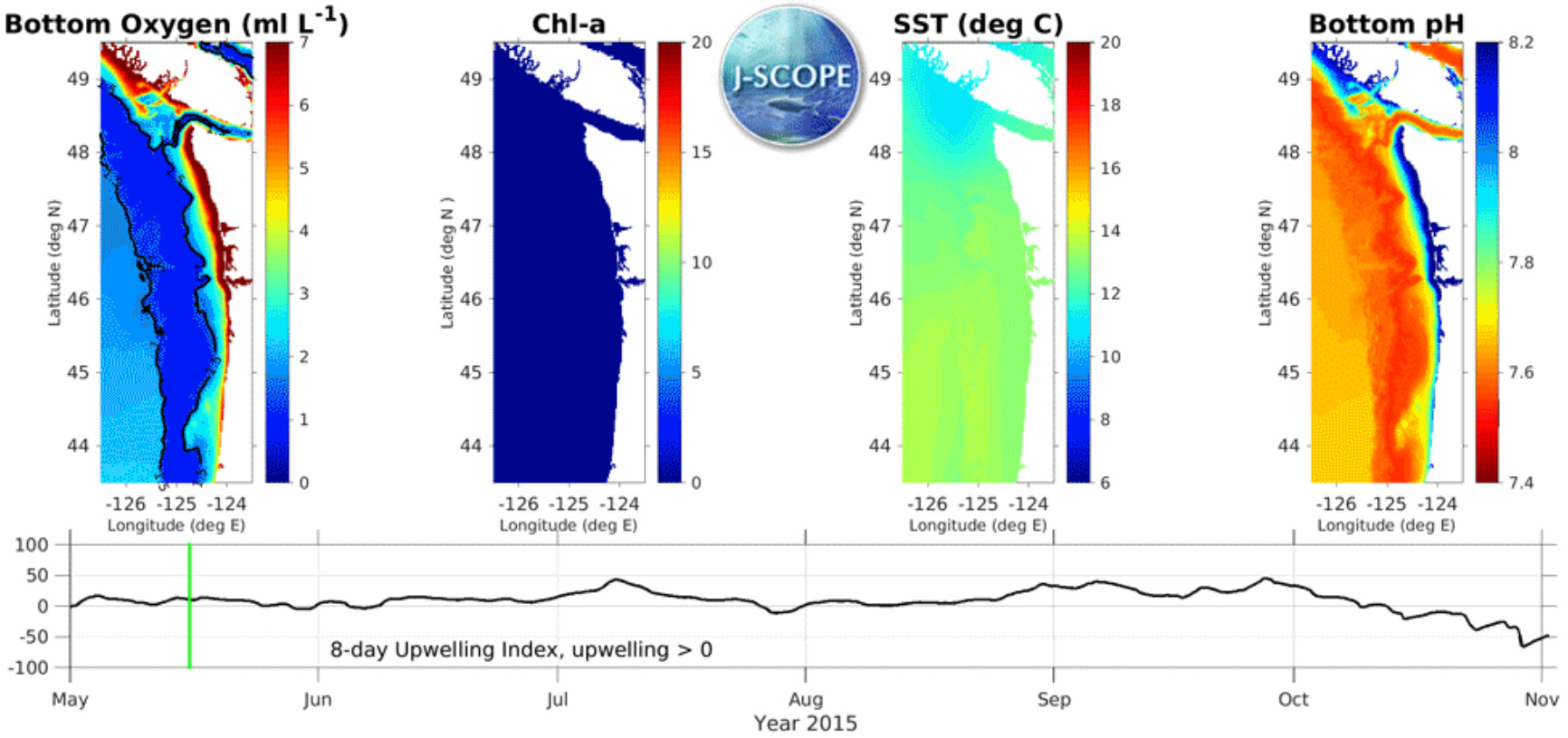
3-Day forecast appears daily on NANOOS



www.nanoos.org

Parker MacCready, Samantha Siedlecki, UW

Breaking ground to seasonal ecosystem forecasting: hypoxia, OA, sardines

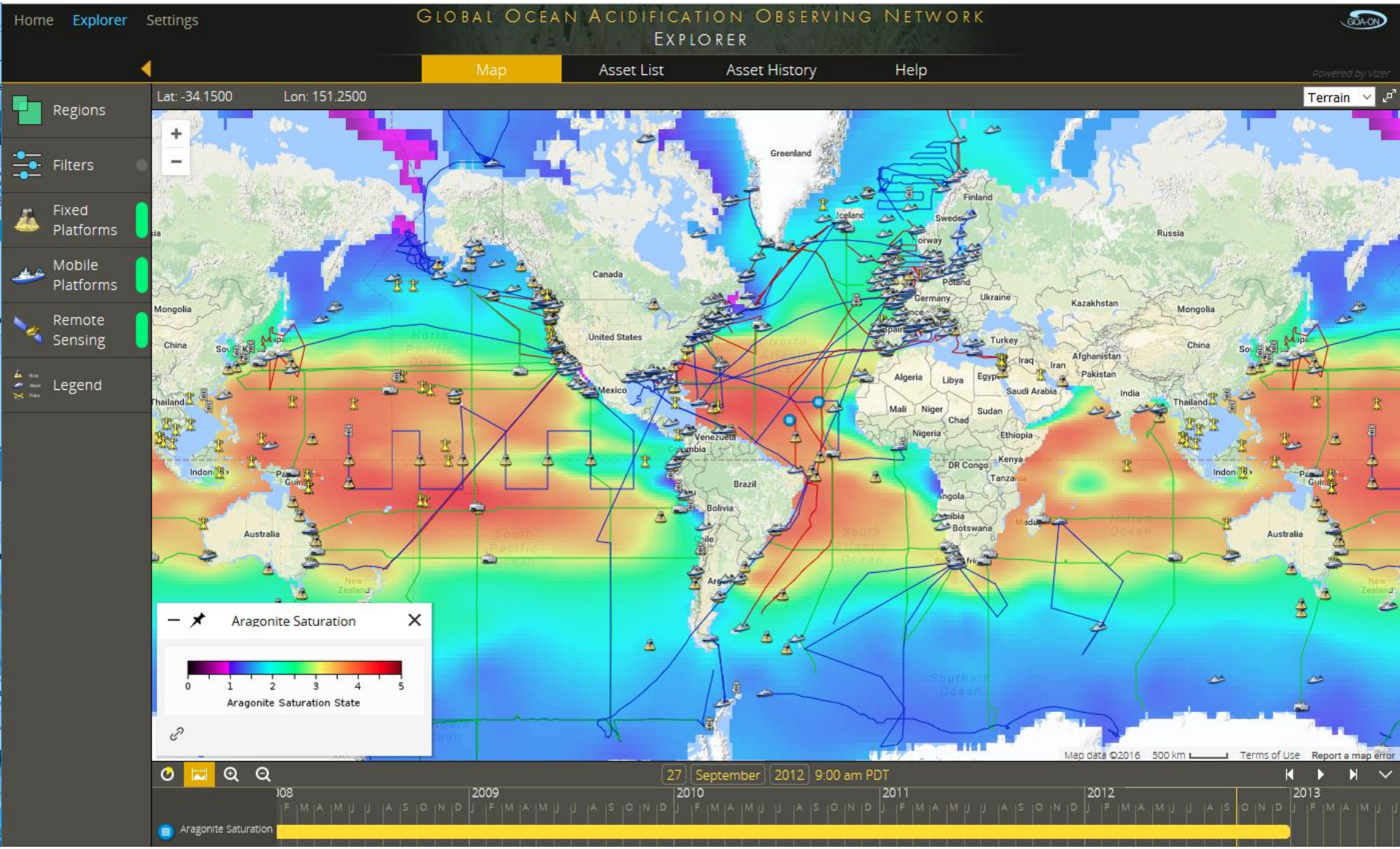


Siedlecki et al., UW

The GOA-ON interactive data portal

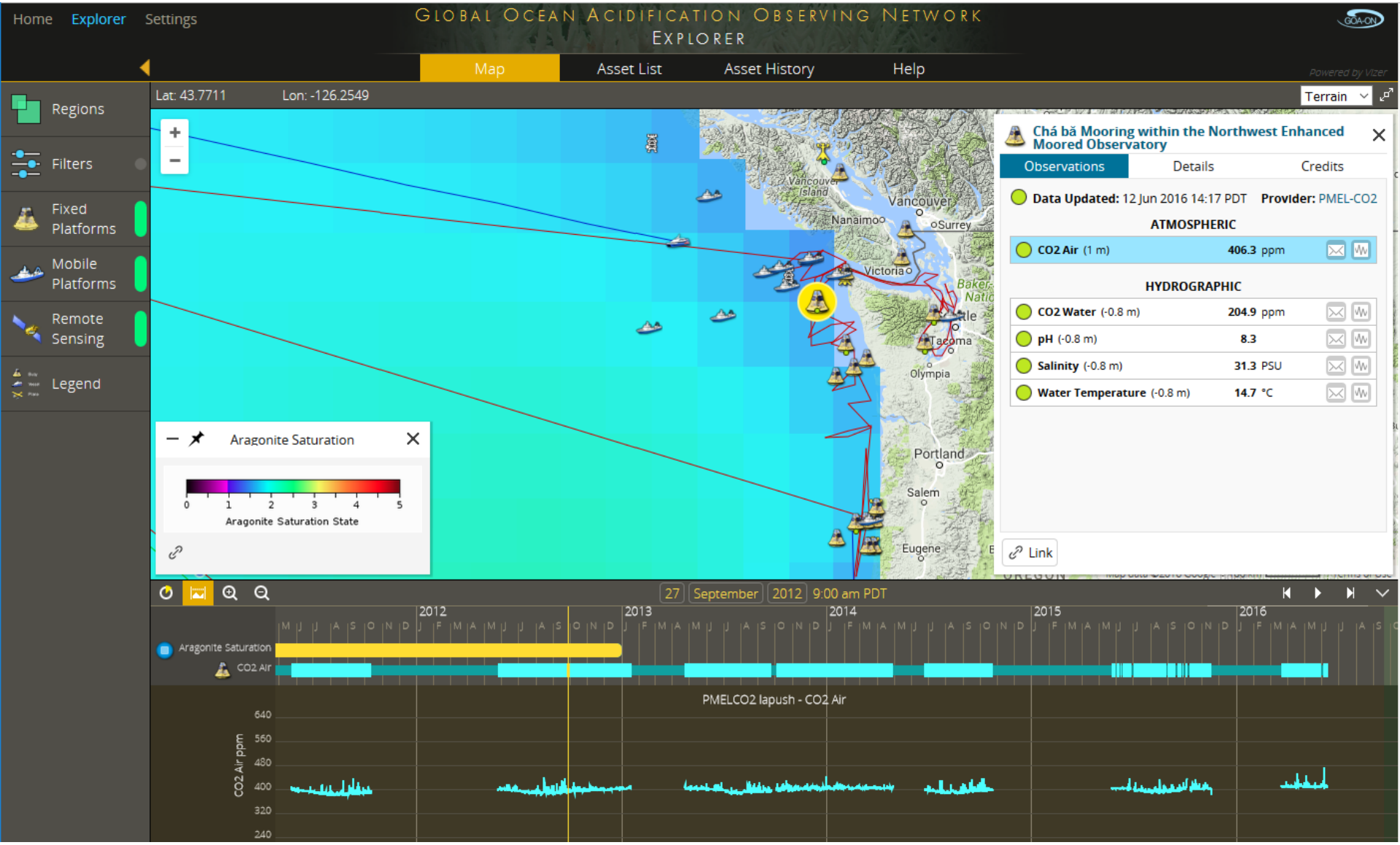
Featuring global OA data, asset inventory, metadata, data synthesis products, etc.

GOA-ON
Global Ocean Acidification Observing Network

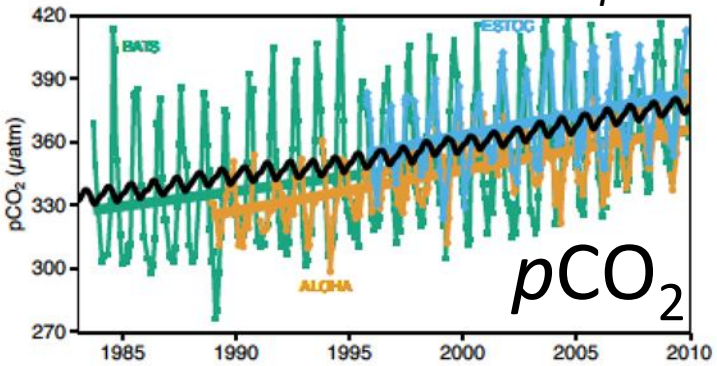


We are GOA-ON !

GOA-ON
Global Ocean Acidification Observing Network



Source: IPCC Report



OA is
a global condition
with
local effects